HYRUM RESERVOIR

Introduction

Hyrum Reservoir is in Cache Valley, in the city of Hyrum. It is one of the few urban reservoirs in the state. Adjacent to the lake is a heavily used state park. The lake is also the focus of a Clean Lakes Phase I study to improve water quality.

Hyrum Reservoir was created in 1935 by the construction of an earth-fill dam. The reservoir shoreline is owned by the State of Utah with mostly unrestricted public access, although fees are charged in improved recreation areas. The reservoir provides recreation, water storage, wetlands for birds and aquatic life, and waterfowl habitat and refuge. Reservoir water is used for crops, watering stock, and other agricultural needs. Water use is not expected to change in the foreseeable future, however, an expansion to 44,300 acre-feet has been proposed for storage of water from the Bear River drainage.

Characteristics and Morphometry

Lake elevation (meters / feet)	1,421 / 4,664
Surface area (hectares / acres)	177 / 438
Watershed area (hectares / acres)	47,139 / 116,480
Volume (m^3 / acre-feet)	
capacity	23,049,217 / 16,290
conservation pool	
Annual inflow (m^3 / acre-feet)	
Retention time (years)	0.30
Drawdown (m^3 / acre-feet)	12,954,237 / 10,502
Depth (meters / feet)	
maximum	25 / 82
mean	12 / 39
Length (km / miles)	2.86 / 1.77
Width (km / miles)	.714 / .44
Shoreline (km / miles)	7.1 / 4.41

Location

County	Cache
Longitude / Latitude	111 51 28 / 41 37 14
USGS Map	Paradise, 1955
DeLorme's Utah Atlas & Gazetteer™	Page 60, A-3
Cataloging Unit	Little Bear-Logan Rivers (16010203)

Recreation

Hyrum Reservoir is in the town of Hyrum in Cache Valley. Routes from US-89 to the reservoir are well marked.

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Hyrum Reservoir is a high recreational and agricultural use

facility. Hyrum State Park is located adjacent to the reservoir and has restrooms, drinking water, overnight camping, utility hook-ups a boat ramp and a fish cleaning station. In addition, there is a private development for recreation located in close proximity to the reservoir which is in an urban/agricultural setting.

The reservoir receives moderate to heavy use. This area is popular with people throughout the state and is also visited by a significant number of individuals from adjacent States. Year round recreational opportunities are available as ice-fishing becomes a more popular form of recreation in the area. In 1992, the park recorded 168,779 visitors, ranging from 1,261 visitors in January to 52,161 in July.

Watershed Description

The watershed high point is 2,788 m (9,148 ft) above sea level, thereby developing a complex slope of 4% to the reservoir. The inflow and outlet are the Little Bear River, with an average stream gradient of 3.1% (166 feet per mile) Porcupine Reservoir is an impoundment of the Little Bear River several miles upstream from Hyrum.

The watershed is made up of mountains, plateaus, mountain valleys, lake terraces, alluvial fans, and mountain foot-slopes. The soil associations that compose the watershed are listed in Appendix III.

The vegetation communities consist of cropland, sage-grass, oak, maple, spruce-fir and aspen. The watershed

receives 41 - 102 cm (16 - 40 inches) of precipitation annually. The frost-free season around the reservoir is 120 - 140 days per year.

Land use in the watershed is as follows: Grazing of domestic livestock on private land (77%), USFS multiple use (16.5%), irrigated pasture and hay fields (3%), dry cropland (3%) and urban (0.5%).

Limnological Assessment

The water quality of Hyrum Reservoir is good, but there have been concerns since the 1950's. According to the Hyrum Reservoir Clean Lakes Phase I study (1994) the issue of degraded water quality conditions are evidenced by extensive late summer blooms of the blue-green *Aphanizomenon flos-aqua*. Phosphorus concentrations frequently exceeded the state indicator value of 25 ug/L during spring runoff. These conditions have resulted in decreased transparency, surface scums and algal mats, noxious odors from these decaying algal mats and changes in food web structure. Low hypolimnetic dissolved oxygen concentrations have occurred in winter and summer. High summer temperatures coupled with low dissolved oxygen have resulted in frequent fish kills. These conditions have compromised beneficial uses of the reservoir.

In a 19971 study, the Little Bear River contributed 97 percent of the phosphorus which entered the reservoir (Luce, 1974). Effluent from a fish hatchery upstream of the reservoir accounted for approximately 40 percent of

the inflow total phosphorus and 60 percent of the inflow dissolved total phosphorus. The study also noted significant contributions (50-60 percent) of orthophosphorus and dissolved total phosphorus from agricultural fields during
spring runoff and substantial contributions of all phosphorus fractions in the summer irrigation return flow.

The trout fishery in the reservoir has historically been of variable quality. Prior to 1973, summer fish kills were common in the reservoir. June through early September were identified as a critical period for trout. In addition, numerous fish have been introduced including goldfish (*Carassius autatus*), channel catfish (*Ictalurus punctatus*) and yellow perch (*Perca flavescens*). Yellow perch is now managed as part of the warm water fishery in the reservoir.

Several restoration projects have been implemented to improve water quality in Hyrum Reservoir. An artificial destratification program was conducted during 1973-74 to reduce blue-green algae abundance and improve fish habitat, but was not successful due to insufficient destratification of the water column. A second aeration effort occurred in 1980-81 to improve summer water quality for trout and to improve carryover of stocked trout into the following year., Aeration was successful in 1980, but less successful in 1981. The reservoir was also chemically treated with a piscicide (rotenone) in 1988 to remove non-game fish before restocking efforts were initiated.

As part of the Clean Lake study in 1992-93 water year the reservoir was sampled monthly from October through April and bi-monthly from May through September, the productive season. Four sites on the reservoir and sites throughout the watershed were sampled to obtain a representative view of water quality within the reservoir and its watershed. Various water quality parameters, including nutrients, bacteria, chlorophyll-a dissolved oxygen and river flow, were measured to assess current water quality in the reservoir and inflow waters.

The results from the current study of Hyrum Reservoir showed improvements in several water quality indicators relative to past conditions. Water transparency was good, with a maximum transparency of 4.6 meters in January and midsummer transparencies ranging from 2.2. to 3.2 meters. Although algal concentrations were high in summer, blooms of *Aphanizomenon flos-aqua* were not present, apparently because an increase in the nitrogen to phosphorus ratio in the reservoir eliminated the competitive advantage of this nitrogen-fixing algae. Chlorophyll-a concentrations followed the seasonal phytoplankton abundance pattern throughout most of the 1992-1993 water year, with concentrations low in winter (0.1 ug/L) but immediately increased to a spring maximum of 13.5 ug/L. Improvements could be attributed to a reduction in dissolved total phosphorus output from the fish hatchery above the reservoir.

Limnological Data

Data averaged from STORET sites: 590167, 590168

Surface Data	1981	1989	1991
Trophic Status	E	M	M
Chlorophyll TSI	-	45.37	48.26
Secchi Depth TSI	35.97	40.97	44.66
Phosphorous TSI	47.35	51.17	36.29
Average TSI	41.66	45.84	43.07
Chlorophyll a (ug/L)	-	4.5	6.0
Transparency (m)	5.3	3.8	2.9
Total Phosphorous (ug/L)	20.0	33	10
pH	8.4	8.5	8.5
Total Susp. Solids (mg/L)	-	-	5
Total Volatile Solids (mg/L)	-	-	5
Total Residual Solids (mg/L)	-	-	<2
Temperature (°C / °f)	20/68	19/67	19/67
Conductivity (umhos.cm)	370	389	367
Water Column Data			
Ammonia (mg/L)	0.08	0.083	0.054
Nitrate/Nitrite (mg/L)	0.36	-	0.23
Hardness (mg/L)	207	-	190
Alkalinity (mg/L)	201	-	178
Silica (mg/L)	-	-	10.3
Total Phosphorous (ug/L)	37.5	37	15
Miscellaneous Data			
Limiting Nutrient	N	N	P
DO (Mg/l) at 75% depth	3.4	6.9	2.9
Stratification (m)	6-11	NO	NO
Depth at Deepest Site (m)	18	14.5	15.2

Surface temperature in the reservoir ranged from 0°C to 20°C. Dissolved oxygen ranged from 7.8 to 9.1 mg/L. This combination of lower temperatures and slightly higher dissolved oxygen concentrations prevented the loss of fish habitat throughout the year.

Trophic State indicators (TSI), a measure of lake productivity, were calculated from total phosphorus, chlorophyll-a, and secchi depth. The TSI for the 1992-1993 water year indicate the reservoir is now mesotrophic compared the historic mesotrophic-eutrophic classification. These date further support an improvement in reservoir water quality.

Although an improvement in water quality was observed, problems were evident with some water quality parameters. Hypolimnetic dissolved oxygen concentrations remained below state criteria, ranging from 1.0 to 4.7 mg/L during summer. The volume-weighted mean total phosphorous concentrations were greater than the state pollution indicator level of 0.25 mg/L throughout the winter. Finally, sporadic, high total and fecal coliform counts in the late fall posed a potential public health problem.

During the 1992-1993 monitoring study, the majority of external nutrient and sediment loading to the reservoir occurred during the runoff. The amount of total phosphorous entering the reservoir, was reduced by 37 percent in 1993 compared to 1971. A reduction in hatchery effluent probably contributed to this observed decrease in dissolved total phosphorous. The relative phosphorous loadings from this source have decreased by almost 90 percent since 1972 as operations at the hatchery were curtailed dudring the study period..

Particulate phosphorous loading increased slightly from 5,380 kg in 1971 to 5,750 kg in 1993. This increase in particulate phosphorous loading suggests that contributions from nonpoint sources may have increased since 1971.

An average of 20,000 kg/day of sediment entered the reservoir (7,200,000 kg/year) during the 1992-1993 water year. More than 60 percent of the inflow sediment was retained in the reservoir. This retention of sediment is consistent with the total phosphorus budget and historical date.

High internal loading of dissolved total phosphorus during the winter and prior to runoff lead to the export of dissolved total phosphorus from the reservoir after the rapid turnover in early spring and export as water is released downstream. As a result there is a net loss of this phosphorus fraction from the reservoir but an increase in dissolved total phosphorus downstream into the Little Bear River. The historic record indicates that Hyrum Reservoir previously acted as a phosphorus sink retaining 60 percent of the total phosphorus and 36 percent of the dissolved total phosphorus entering the reservoir. During the 1992-1993 water year, however, a net export of dissolved total phosphorus occurred. Reservoir outflows in 1993 were 69 percent of 1971 outflows. The observed 1992-1993 seasonal changes in internal dissolved phosphorus loading appear to be related to phosphorus dynamics at the sediment-water interface and macrophyte decay.

Reduced phosphorus loading resulted in higher nitrogen to phosphorus ratios throughout the 1992-1993 water year. As a result, blue-green algae were less competitive, and nuisance blooms of the blue-green *Aphanizomenon flos-aqua* did not occur.

Although an improvement in the biological condition of the reservoir was observed, several of the water quality parameters measured in 1993 were unimproved. From January to September more than 30 percent of the reservoir had dissolved oxygen values below the 30-day average aquatic wildlife criteria of 6.5 mg/L. In addition, 56 percent of total phosphorus values exceeded the state indicator of 0.025 mg/L. Fecal coliform and total coliform also violated state criteria three and six percent of the time, respectively.

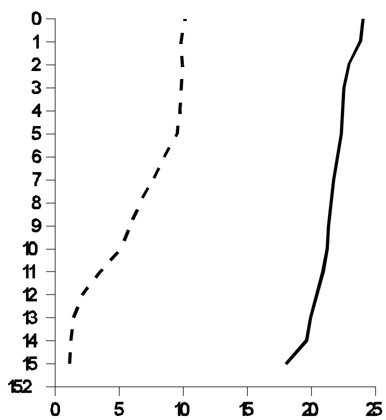
Restoration efforts should be directed towards the development and implementation of a water quality management plan which will bring water quality parameters into compliance with state beneficial use criteria. Permanent water quality improvement in Hyrum Reservoir will rely on a long term reduction of nutrient and sediment loading from the watershed. In order to maintain present water quality conditions in Hyrum reservoir, it is imperative that the current phosphorus point source loading to the reservoir not increase. Further improvements in water quality can be expected by reducing the external total phosphorus loading to a total maximum daily load of 6.4 kg/day by watershed and riparian zone improvements.

Implementation of best management practices (BMP's) and stabilization of sections of streambanks are required to reduce watershed input of sediments and nutrients from the Little Bear River. A large scale restoration project, the Utah Little Bear Hydrologic Unit Area Plan, was initiated in 1990 to address nonpoint source water pollution associated with agricultural and rangeland practices. The goals of this project are to reduce streambank and rangeland erosion.

While large scale watershed management addresses the primary pollution source, supplementing this management program with other restorative measures may provide temporary and immediate improvement in water quality. Moreover, once external loading is reduced, additional reservoir treatment may be required to offset prolonged eutrophication conditions in the reservoir due to the residual internal phosphorus loading which is the result of historical eutrophication. Several of these treatment options are described in detail in section 5.4 of this document. However, these restoration measures will not be effective unless external, point and nonpoint source loading to the reservoir is reduced.

In 1989 and 1991 samples were collected twice on Hyrum Reservoir. The water is considered to be hard with a hardness concentration of 199 mg/L ($CaCO_3$). Although the profile of August 13, 1991 does not show stratification in the reservoir the reservoir does stratify and as indicated in the profile oxygen depletions downward in the water column do occur. These types of conditions reduce available habitat for a fishery, and increase the internal loading of phosphorus as anoxic conditions develop, especially during the winter season.

The reservoir has been classified as a mesotrophic system during all of our periods of study. Although nitrogen /phosphorus ratios indicate the reservoir was nitrogen limited in 1981 and 1989, recent data (1991) and data from the Phase I study indicate that the reservoir is limited during the productivity season.



D	ºC	pH	DO	Cond
0	24.0	8.5	10.1	342
1	23.8	8.4	9.8	342
2	22.9	8.4	9.9	340
3	22.5	8.4	9.8	341
4	22.4	8.4	9.7	343
5	22.3	8.4	9.5	343
6	22.0	8.2	8.5	353
7	21.7	8.1	7.6	356
8	21.5	8.0	6.6	363
9	21.3	8.0	5.8	369
10	21.2	7.9	5.1	373
11	20.9	7.8	3.5	373
12	20.4	7.6	2.1	377
13	19.9	7.6	1.4	386
14	19.6	7.5	1.2	390
15	18.0	7.5	1.1	385
15.2	---	---	---	---

Temp DO

The fishery is impaired due to extensive algal blooms and some macrophyte production. The fishery and other recreational components are impacted due to the high enrichment of the waters of the reservoir. These high levels of nutrients lead to high algal production and macrophyte phosphorus development. High algal production reduces dissolved oxygen concentrations and creates other problems associated with the fishery.

In addition, the trout population in the reservoir is infested with anchorworm (*Lernaea cyprinacea*) and the downstream fishery conditions are effected due to flow reductions from the reservoir. As reported by DWR the reservoir maintains a population of perch (*Perca flavescens*), rainbow trout (*Oncorhynchus mykiss*), goldfish (*Carassius autatus*, channel catfish (*Ictalurus punctatus*), largemouth bass (*Micropterus salmoides*), smallmouth bass (Micropterus dolomieui), kokanee (*Oncorhynchus nerka*), and splake, a cross between brook trout and lake trout (*Salvelinus fontinalis* X *Salvelinus namaycush*). DWR typically stocks the reservoir with 8,000 fingerling and 1,000 catchable rainbow trout annually. Largemouth bass were stocked in the reservoir in 1990.

Waterskiing and swimming are impaired due to the large amounts of algae present in the summer months. In addition extensive growth of macrophytes in the upper reaches of the reservoir prohibit boating and impair water quality conditions.

For a complete analysis of the limnology refer to the Clean Lakes Phase I Study.

Phytoplankton in the euphotic zone for August 13, 1991 include the following taxa (in order of dominance)

Species	Cell Volume (mm^3/liter)	% Density By Volume
Sphaerocystis schroeteri	11.101	93.29
Ceratium hirundinella	5.617	3.25
Eudorina elegans	5.560	3.22
Wislouchiella planktonica	0.222	0.13
Dinobryon divergens	0.093	0.05
Pennate diatoms	0.047	0.03
Oocystis sp.	0.033	0.02
Chlamydomonas globosa	0.004	0.00
Total	11.798	
Shannon-Weaver [H']	0.30	
Species Evenness	0.15	
Species Richness	0.27	

The phytoplankton community is dominated by green algae, however historically there has been a dominance by the blue-green algae, *Aphanizomenon flos-aqua*. A similar type of dominance and composition was exhibited during the Phase I study period. However, *Aphanizomenon* colonies were present in August and replaced with colonies of Microcystis in September.

Information	
Management Agencies	
Bear River Association of Governments	752-7242
Division of Wildlife Resources	538-4700
Division of Water Quality	538-6146
Recreation	
Bridgerland Travel Region (Logan) / Logan Chamber Of Commerce	752-2161
Hyrum State Park	245-6866
Reservoir Administrators	
DOI	524-5403

Pollution Assessment

Nonpoint pollution sources include the following: Sedimentation and nutrient loading from grazing. Litter, human waste and chemicals from recreation. Nutrients and sedimentation from agricultural practices in the watershed.

The one major point source of pollution that discharges into tributary waters in the watershed area of Hyrum Reservoir is Whites Trout Farm. It contributes a major nutrient-loading resulting in increased production in the reservoir and degraded lake water quality.

Beneficial Use Classification

The state beneficial use classifications include: recreational bathing (swimming) 2A, boating and similar recreation (excluding swimming) (2B), cold water game fish and organisms in their food chain (3A) and agricultural uses (4).